U. S. DEPARTMENT OF AGRICULTURE
FARMERS' BULLETIN No. 1565

SHALL I BUY A COMBINE ?

SMALL GRAINS, soy beans, clovers, grain sorghums, and other crops have been harvested and threshed successfully with combines. Combines can also be used for stationary threshing.

The advantages of the combine in comparison with other methods of harvesting and threshing are the saving of labor, the eliminating of transient labor, the early clearing of fields for tillage operations, the distributing of the straw on the land, and the getting of the grain to market earlier.

The disadvantages are the large investment required, the large amount of power consumed, the greater risk from damp grain, the greater risk to crops from storms, and the difficulty of saving the straw for feed and bedding.

Combines range in size from machines which cut an 8-foot swath to those which cut a 24-foot swath. Ten-foot combines will cut 20 to 25 acres a day and 15-foot combines 30 to 35 acres or more. Combines cost from $1,000 to $3,000 and require 6 to 12 horses, or tractors of from 9 to 20 drawbar horsepower.

A combine should not be purchased for harvesting less than 100 to 150 acres annually. For smaller acreages other methods will usually be more economical.

Harvesting and threshing losses need be no greater with combines than with other methods of harvesting and usually are less.

This bulletin is based on information obtained cooperatively by the Division of Farm Management and Costs of the Bureau of Agricultural Economics, the Office of Cereal Crops and Diseases of the Bureau of Plant Industry, the Division of Agricultural Engineering of the Bureau of Public Roads, and the agricultural experiment stations of Kansas, Montana, Nebraska, Oklahoma, and Texas, in 1926; and of Illinois, Indiana, Pennsylvania, South Dakota, and Virginia, in 1927. A complete discussion of the 1926 study is given in Technical Bulletin No. 70, The Combined Harvester-Thresher in the Great Plains.

Washington, D. C. Issued April, 1928

SHALL I BUY A COMBINE?

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THE PROBLEM of deciding whether to purchase a combine or to continue harvesting by the older methods is one that many farmers are trying to solve. This bulletin discusses the most important points to be considered by those who are endeavoring to decide whether to purchase one of these machines. It is based on information obtained from owners of combines and embodies the results of studies conducted in different sections in the Great Plains, in the Corn Belt, and in Eastern States.

The ability of the combine to harvest and thresh grain successfully has been demonstrated from the time the early machines were perfected. The first combine was built over 50 years ago. The early models were soon improved to the extent that the machines showed their value for harvesting wheat in the large wheat-growing districts of the Pacific coast. The small, prairie-type combine equipped with an auxiliary engine, such as is now used in the Great Plains, the Corn Belt, and Eastern States, was introduced and its adaptability demonstrated in the wheat fields of Oklahoma and Kansas in 1918.

The advantages of the combine, in comparison with other methods of harvesting and threshing as reported by farmers are the saving in harvesting and threshing costs, the decreased labor, the elimination of hired help, the earlier clearing of the field for tillage operations, the distribution of the straw on the land, and the earlier marketing of the crop.

The chief disadvantages of the combine are the large investment necessary, the large amount of power required, the fact that the grain is more likely to be damp, the greater risk to crops from storms, and the loss of straw for feed and bedding unless additional labor is expended in picking up the straw after the combine.

CROPS THAT CAN BE HARVESTED WITH COMBINES

Wheat, barley, oats, rye, emmer flax, grain sorghums, buckwheat, rice, soy beans, cowpeas, sweet clover, red clover, alsike clover, timothy, and alfalfa have been harvested and threshed with combines with varying degrees of success.

In the Pacific Coast States wheat and barley are practically the only crops harvested with a combine because the machine is used in districts where these are the principal small-grain crops. As the method used in threshing, separating, and cleaning the grain in a combine is identical with that used in most stationary threshing machines, the combine was tried for harvesting other crops soon after it was introduced into the Great Plains and the regions further east. In the Corn Belt and the Eastern States wheat, oats, barley, buckwheat, soy beans, sweet clover and other clovers, and a few miscellaneous crops have been harvested successfully. Farmers in the Great Plains, have also used combines successfully when harvesting oat, rye, emmer, flax, and grain sorghum.

WHEAT

Ordinarily no difficulty is experienced by operators in harvesting wheat, as it usually stands well after ripening. In lodged grain some difficulty may be encountered, as it is necessary to cut the straw lower down the stalk. Under humid conditions wheat tends to bend down after maturity and may be completely lodged if allowed to stand too long, or it may lodge before it is ripe. The added bulk caused by the longer straw may clog the machine before the grain reaches the cylinder or may so overload the sieves and chaffer that it may be necessary to cut a narrower swath. If the crop is harvested at the proper stage of maturity and dryness the grain will be equal in quality and condition to that harvested and threshed by other methods. Shattering of the grain seldom occurs in most varieties of wheat grown east of the Rocky Mountains even when it is left three or four weeks after maturing.

OATS

Oats that are erect can be harvested with a combine as easily as can wheat. The oat plants frequently fall over shortly after maturity, especially during wet weather, and this greatly increases the difficulty of combine harvesting. Under dry conditions oats shatter rather easily after they are fully mature. If green weeds extend up through the lodged oats the threshing of the grain is interfered with. Owing to the danger of a lodged crop, the combine should not be depended upon to harvest more oats than can be cut within four or five days after the crop reaches maturity. The adjustments of the combine necessary for threshing oats consist of cutting down the wind, opening up the chaffer sieves, and removing the small wheat screen.

BARLEY

Barley can be harvested with a combine almost as easily as can wheat. The varieties of barley grown in the Great Plains and in the Eastern States are more susceptible to lodging and shattering

than are the barleys of the Pacific Coast States, or most varieties of wheat. The threshing of barley with the combine is only slightly different from the threshing of oats. The concaves should be raised slightly, and the wind should be increased.

RYE

Rye usually is taller than other small grains and the straw is tougher, but it is not too tall for combine harvesting. Rye shatters more easily than does wheat and is more easily threshed from the heads. Rye heads sometimes nod so much that the curved heads are thrown out by the combine reel. This loss can be reduced by placing wide slats on the reel.

EMMER

Emmer (speltz) can be harvested with the combine successfully. The crop stands well but is rather susceptible to shattering. Emmer is threshed with about the same adjustments that are used in threshing oats, except that the concaves are lowered more or more concaves are removed.

FLAX

Farmers who use their combines for harvesting flax state that it does excellent work after frost, when the plants are dry and brittle. Before frost a combine will do good work in clean fields, but in weedy fields considerable flax is lost because it is carried over with green weeds and straw.

GRAIN SORGHUMS

The combines now available are not fully adapted to harvesting grain sorghums because of the heavy stalks and the irregular height and irregular ripening of this crop. Many heads are lost in harvesting uneven sorghum crops. When grain sorghums are harvested with a combine it is necessary to cut off 12 to 20 inches of the stalk along with the head. When these stalks are green much of the juice is crushed out as they pass through the machine, with the result that the moisture content of the threshed grain is increased. When the plants are ripe or killed by frost before harvest the threshed grain is dry. But if the crop is allowed to stand until after a frost a high wind or storm may cause it to lodge. If it does, it will be impossible to use a combine, and the crop will have to be harvested by hand. Grain sorghums which are mature, erect, and of even height can be harvested with the combine with very little loss if the machine is properly adjusted. The adjustments consist of the use of wider reel slats, and screens at the back and end of cutting platform; reduced cylinder speed; and the lowering or removing of concaves.

SOY BEANS

Nearly every farmer who owns a combine and who raises soy beans uses the machine to harvest his crop. (Fig. 1.) Harvesting with a binder, a bean harvester, or a mower is often unsatisfactory because of the heavy bean losses. Many owners in the Corn Belt purchased their combines especially for harvesting soy beans.

Owing to the lateness of the harvest season and the habit of growth of soy beans, the harvesting of this crop is accompanied with more hazard and difficulty than is the harvesting of small grains. Harvesting is aided by early sowing of early-maturing varieties which shatter little. If the soy beans are cut sufficiently early the disk and wheat drill may be pulled directly behind the combine, and the strip of land seeded to wheat will be covered with a thin layer of straw on the next round of the combine.

The loss of beans harvested by the combine is greater than for small grains, but there is a decided saving in combining beans over other methods of harvesting. The greatest losses in harvesting are due to low pods which are missed by the cutter bar, the lowest adjustment of which cuts about 4 inches or more above the ground. Thicker planting tends to produce taller plants with fewer low pods.

FIG. 1.—In Illinois and Indiana, on farms where combines are owned, the machine has superseded the binder and mower for harvesting soy beans, as it saves a larger percentage of the crop

In harvesting soy beans the speed of the cylinder should be reduced approximately 50 per cent below that required for wheat, to prevent cracking the beans, the separating unit of the machine being kept at the same speed to insure proper cleaning and quick disposal of the green material. If the crop is uniformly mature no concave teeth are needed, but concaves must be used if beans are not thoroughly ripe, in order to insure clean separation. The cylinder can be slowed down when soy beans are being threshed either by placing a smaller pulley on the motor shaft or a larger pulley on the cylinder shaft, and the usual speed of the remainder of the threshing unit can be maintained by putting a larger sprocket on the driving end of the cylinder shaft. These are necessary items of equipment for the proper operation of the machine in both bean and pea harvest.

BUCKWHEAT

A few farmers have harvested buckwheat with combines. Difficulty has been encountered because of the irregular ripening of the crop and the presence of green stalks at harvest time.

RICE

Some rice has been harvested with the combine in recent years, but the use of the combine was successful only when accompanied by the artificial drying of the threshed grain.

CLOVER, ALFALFA, AND TIMOTHY SEED

The common methods of harvesting sweet clover have always been more or less unsatisfactory because of the large quantity of seed lost by shattering. In the last two or three years some growers have tried the combine and found that by using it they were able to save considerably more seed than by other methods. Because of its uneven ripening and rank, spreading growth sweet clover is rather difficult for the combine to handle. Threshed seed frequently has to be dried because of the immature seeds and green material which it contains. The results obtained, however, may offset the difficulties encountered. Other clover, as red, alsike, and mammoth red, have also been successfully harvested by combines. Some combine owners have used their machines for harvesting timothy and alfalfa for seed.

THE COMBINE AS A STATIONARY THRESHER

The use of a combine need not be confined entirely to harvesting standing crops. Many farmers thresh small acreages of bound grain, such as oats, with a combine if the straw is desired for feed or bedding. Many grain-sorghum growers who harvest their crop with headers or with corn binders, or by hand, thresh the heads later with the combine.

If the combine is to be used extensively as a stationary thresher, a feeder and straw carrier will add to its efficiency. The feeder is attached in place of the cutting and elevating platform and serves to carry the bundles into the cylinder of the combine. When combines are used without a feeder for stationary threshing, the reel and sickle are removed, and the bundles are pitched on to the platform canvas. The bundles are then carried into the cylinder after the bands are cut.

When a straw carrier is attached the straw can be stacked better and more easily. If the straw is not to be saved stacking is unnecessary as the combine can be moved at intervals rather easily.

The threshing portion of the combine is nearly identical with the ordinary threshing separator and is adjusted in a similar manner.

TYPES OF COMBINES AND EQUIPMENT

In purchasing a combine there are several types from which to choose. The type first developed for use in the Great Plains is equipped with an auxiliary engine and is pulled by horses or tractor. (Fig. 2.) This type is made in several sizes, the size being governed by the length of the cutter bar which ordinarily is 9, 10, 12, 15, or 16 feet long. Of these sizes only the first three are common in the Corn Belt and in the Eastern States, whereas in the Great Plains the majority are of the larger sizes. A few machines with 20 and 24 foot

cutter bars are used in the Great Plains, but these are too large except for use on big wheat ranches.

Combines with a 9-foot or 10-foot cut drawn by a tractor with a direct power drive from the tractor were introduced in 1926.

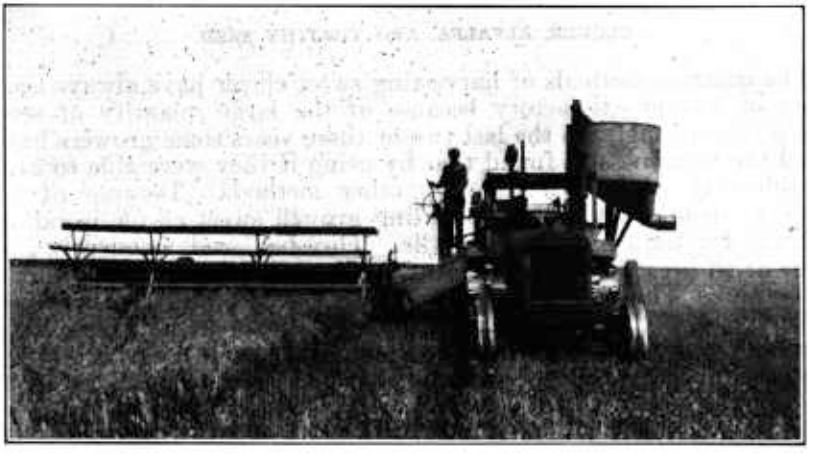

FIG. 2.—A large type of combine used in the Great Plains and used to a limited extent in the Corn Belt. A crew of two men with this machine can harvest and thresh 30 to 50 acres of grain per day

(Fig. 3.) Such a machine has advantages in that it can be operated by one man and in that it requires a smaller investment than do the large machines which have auxiliary motors. It is not satisfactory

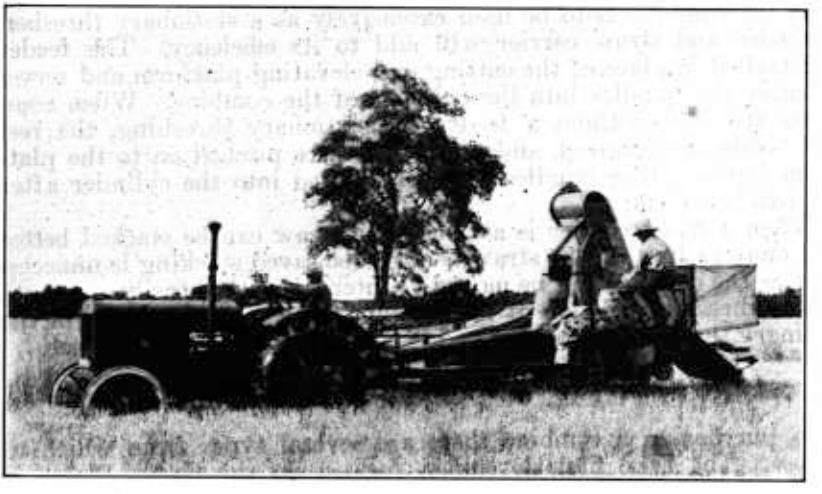

FIG. 3.—This type of power drive combine is built in two sizes. It requires a smaller investment than does a machine of the same size that is equipped with an auxiliary motor. It has a further advantage in that it can be operated by one man if the grain is handled in bulk. Two men are required on the outfit shown here because the grain is being threshed into sacks

when a large quantity of straw is to be cut or in loose soils because there is insufficient power for threshing unless the tractor is run in low gear.

A third type of combine, also introduced in 1926, is mounted on the tractor from which it obtains its power. (Fig. 4.) This machine has an 8-foot cutter bar located directly in front of the tractor and differs radically from all others in that an auger is used instead of canvases on the cutting platform. These small power-driven machines are used mostly on farms which have small acreages of grain.

Special hillside combines with leveling devices are built by most manufacturers for use in the Pacific Northwest. These combines can be used on slopes as steep as can be harvested with any harvesting machinery. Hillside combines of the smallest size may find a place in some portions of the East.

The 8-foot combines require a certain make of tractor for operation, with about 9 drawbar horsepower; the 9 and 10 foot power take-off combines require tractors with about 15 drawbar horsepower. The 9 and 10 foot combines with an auxiliary motor require about 6 horses, or tractors with 9 to 12 drawbar horsepower. The 12-foot

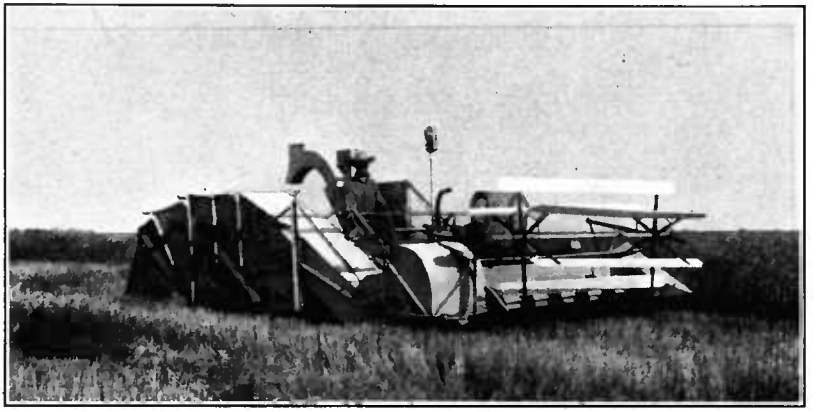

FIG. 4.—The smallest type of combine now on the market. On this machine the cutter bar is directly in front of the tractor, and the machine is operated by one man

machines require 6 to 8 horses, or tractors of 12 to 15 drawbar horsepower; the 15-foot and 16-foot machines about 8 to 10 horses, or tractors of 15 drawbar horsepower; the 20-foot machines usually require about 12 horses, or tractors with 20 or more drawbar horsepower. (Fig. 5.) On the hilly farms in the Pacific Northwest, which have loose ashy soil, combines with auxiliary engines usually are drawn by 12 to 30 horses.

EXTRA EQUIPMENT

Many combine operators may want some extra equipment which is not included in the purchase price of their machines. The chief items of equipment which may be added to the machine are the grain tank, the grain-wagon hitch, the brakes, the transport wheel or truck, the extension to the cutter bar and platform, the straw spreader, and the straw buncher. Other items of less importance are the sacking attachment, the self-feeder, and the straw carrier. The latter two are used only for stationary threshing. Sprockets

and pulleys for changing the speed of the reel and cylinder when threshing peas, beans, and grain sorghums are also available, as are clover and alfalfa seed attachments, special sieves, and windrow and shock pick-up attachments.

GRAIN TANK

If the grain is hauled by motor truck there is a distinct advantage in using the grain tank on the combine, as the grain can be run directly from this tank to the truck, thus eliminating the labor of scooping. If grain is stored on the farm or hauled to market in wagons the use of a grain tank on the combine may not save any appreciable amount of labor. Many combines now come equipped with grain tanks. (See figs. 1, 2, and 4.)

GRAIN-WAGON HITCH

A combine which is not equipped with a grain tank or sacking attachment usually requires a grain-wagon hitch so that the grain

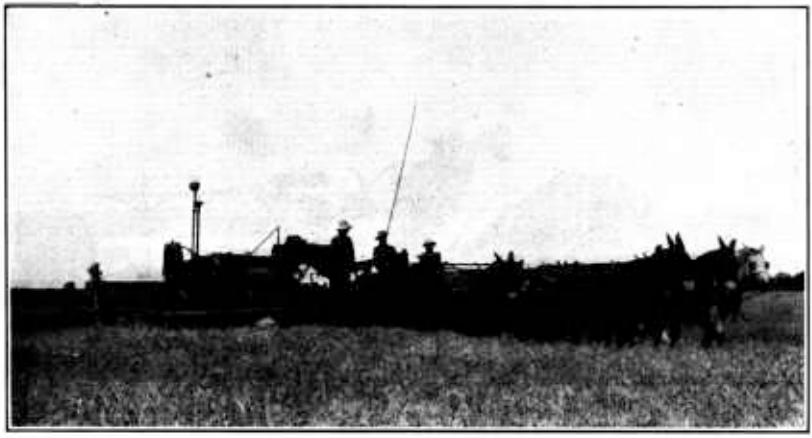

FIG. 5.—Horses or mules are sometimes used to pull the combine, but the tractor is generally considered to be more steady and reliable power

wagon can be trailed along by the combine, thus saving the time of a man and team. When one wagon is full, another can be substituted with little lost time.

BRAKES

All sidehill and some prairie-type combines are equipped with brakes. Brakes are necessary in hilly fields and when the combine must be pulled over roads which have steep grades.

TRANSPORT WHEEL OR TRUCK

A transport wheel or truck often is needed to carry the cutter platform when a combine is being moved along roads or lanes which are too narrow to permit the machine to pass with the cutter platform attached. The platform folds back or up on most machines, but on others it must be removed and carried on a truck. Some of the folding platforms require transport wheels.

EXTENSION CUTTER BAR AND PLATFORM

Most combines are equipped with cutting platforms which are long enough for ordinary conditions. If yields are low the threshing unit can handle more grain than the regular platform will cut, and extensions of 2 to 4 feet in length can be attached to the platform and reel, and a new sickle of the right length can be provided. These extensions are desirable in regions which are subject to drought and consequent light crops.

STRAW SPREADER

On most machines straw spreaders are optional equipment. The spreader distributes the straw behind the machine uniformly and not in a narrow windrow. When the straw is spread it can be plowed under without difficulty, but when left in a narrow strip it can be saved by the use of a hay loader and straw rack or raked in piles with a hayrake.

STRAW BUNCHER

Straw bunchers which hold the straw and drop it in piles can be attached to the rear of most makes of combines. The dumping is accomplished with a trip rope. Straw bunched in piles is convenient either for hauling, for field baling, or for burning.

OTHER ATTACHMENTS

If combined grain is to be handled in sacks instead of in bulk, a sacking platform and sacking spouts are necessary. (Fig. 3.) These attachments permit the sacks to be filled, tied or sewed, and dropped on the ground while the combine is operating.

A self-feeder and a straw carrier are necessary when the combine is used as a stationary thresher.

For auxiliary-motored combines a smaller pulley or sprocket should be used on the crank shaft of the motor for reducing the speed of the cylinder when beans, peas, and grain sorghums are being threshed; otherwise some grains may be cracked. A larger sprocket on the driving end of the cylinder shaft will then maintain the speed of the remainder of the threshing unit.

Recleaners, fine screens, and corrugated teeth are extra equipment needed for threshing clover and alfalfa.

Attachments are now available for some combines which will pick up the loose unthreshed crop from a windrow or the bound crop from a shock row and carry it into the combine for threshing. When this equipment is used the grain is first cut with a binder or header, or the cutting platform of the combine detached and used as a header, then left in shocks or windrows to ripen and dry. After it is dry it is picked up and threshed with the combine.

COST OF COMBINES

The small 8, 9, and 10 foot power-driven machines cost $1,000 to $1,200. The auxiliary-motored machines ranging in size from 9 to 16 feet cost from $1,500 to $3,000. Equipping the combine with some

of the items of extra equipment may increase the first cost as much as 10 per cent.

On account of the large investment, farmers who have only small acreages of grain to harvest should consider carefully the first cost of different types of harvesting machinery before purchasing a combine. The possibility of doing custom work for neighbors should not be given much consideration in making a choice in favor of the combine, because as more machines are put into use returns from this source will become more limited each year. Farmers who have small acreages may sometimes find it advisable to buy a machine in cooperation with neighbors. If the harvesting equipment is nearly new it may be advisable to continue its use for several years longer before disposing of it and buying a combine.

Unless a tractor of sufficient horsepower to pull a combine with an auxiliary engine is already owned it will be necessary to buy one or to use horses to pull the combine. Many Corn Belt and many eastern farmers, however, do not have enough horses to pull a combine. Horses are considered satisfactory for use on these machines but only a few operators use them. If a power-driven combine is purchased it usually will be necessary to use a tractor of specific make and size having a power take-off attachment.

RATE OF HARVESTING

The rate of harvesting with a combine varies with the crop, the yield, the size of machine, the size of fields and crew, rate of travel, and length of day.

The 10-foot machines will cut an average of 20 to 25 acres of small grain in a 10-hour day and a 15-foot auxiliary-motored machine will cut about 35 acres per day. In 15 working days the 10-foot machine should be able to harvest 350 acres and the 15-foot machine 500 acres. In the East, where fields are rougher, smaller, and more irregular and the straw is heavier than in the Great Plains, smaller acreages would be cut. In harvesting soy beans in the Corn Belt the 10-foot combines averaged about 2 acres per hour for a six-hour day. A 15-foot combine will harvest about 24 acres of grain sorghum per day.

As many as 650 acres of wheat have been cut in a season with a 10-foot power-driven combine, and 1,100 acres have been cut with a 15-foot machine in the Great Plains. In the Corn Belt in 1927 the maximum acreage cut with a single 10-foot combine was 675 acres. This acreage included wheat, oats, buckwheat, and millet. A longer harvesting period is possible where several crops or varieties are grown which mature at different times.

In lodged or very weedy grain the acreage cut per day or per hour will be much lower than that in clean erect grain.

COST OF COMBINING

The chief items of operating expenses in combining include the use of a tractor or horses, fuel, lubricants, labor, and repairs on the combine.

Tractors which are pulling combines with auxiliary engines consume about three-fourths to 1 gallon of fuel per acre and 1 gallon of

oil to 20 or 30 acres. Tractors with a power drive for the combine consume about 1¼ to 1½ gallons of fuel per acre. Auxiliary engines on the combines consume about one-half to three-fourths gallon of fuel per acre and about 1 gallon of oil for 40 to 60 acres. Eight-foot combines require only one man to operate them; 9 and 10 foot combines require one or two men, 12 to 16 foot combines two and sometimes three men; and the 20-foot combines three men for operation, all exclusive of grain hauling. The expense for repair parts averages about 10 cents per acre harvested. Repairs usually are furnished free during the first year of operation of the combine, providing the broken part shows defective material or workmanship. The longer a machine is used the greater the repair costs become.

Combines in the Great Plains, in the Corn Belt, and in the Eastern States, if operated and adjusted properly, may last about 10 years The 10-foot combine with auxiliary motor, which is the size and type in most common use in these regions, costs about $1,500. On such a machine the yearly depreciation and interest charge would amount to $195. (See Table 1.)

TABLE 1.—*Depreciation and interest charges per acre for 10-foot and 16-foot combines harvesting various acreages, and total costs per acre for harvesting and threshing with 10-foot and 16-foot combines, 8-foot binders, and 12-foot headers*

Acres cut annually	Depreciation and interest charges		Total costs				
	10-foot combine	16-foot combine	10-foot combine in Corn Belt	16-foot combine in Great Plains	8-foot binder [1]		12-foot header [1]
					Corn Belt	Great Plains	
50	$3.90		$5.13		$4.04	$4.40	$3.46
100	1.95	$3.57	3.18	$4.65	3.72	4.08	3.27
150			2.53	3.43	3.62	3.97	3.21
200	.98	1.78	2.21	2.86	3.56	3.92	3.18
250			2.01	2.51			3.16
300	.65	1.19	1.88	2.27			3.14
400	.49	.89	1.72	1.97			
500	.39	.71	1.62	1.79			
600	.32	.60	1.55	1.68			
700		.51		1.59			
800		.45					

[1] Including cost of hired separator for threshing.

In the Great Plains, where the annual acreage cut is larger, operators estimate a life of about eight years for their machines. A 16-foot combine in this region costs about $2,300. The depreciation and interest charge on this machine amounts to $357 annually.

The total costs of harvesting small grains with a 10-foot combine in the Corn Belt and with a 16-foot combine in the Great Plains in 1927 are shown in Table 1. These costs include depreciation, interest, repairs, fuel, and oil for both the combine and the tractor and a charge for all labor (exclusive of grain hauling) at going wages in 1927.

The table also shows the costs when an 8-foot binder and a hired stationary separator were used in the Corn Belt and in the Great Plains, and the costs when a 12-foot header and hired stationary

thresher were used in the Great Plains. The slightly larger acre cost for the binder in the Great Plains is due to the higher wage rates paid in that region. With the exception of twine, the header costs include the same items as do the estimates for the binder. These costs include depreciation, interest, repairs, and twine for the binder and all labor and horse work (exclusive of grain hauling), and a charge for threshing based on rates used for custom threshing in 1927.

For 50 acres a year the cost of combining is considerably greater than is the cost of harvesting with a binder and hiring the threshing done with a stationary separator. For 100 acres a year the cost with a 10-foot combine is slightly less than with a binder, and for 150 and 200 acres there is a substantial difference in cost in favor of the combine.

In the Corn Belt and in the Eastern States the season for harvesting usually is not long enough to allow one binder to harvest more than 200 acres a year, whereas a 10-foot combine can harvest over twice as much.

For 50 acres a year the cost of combining with a 16-foot machine would be prohibitive. The cost of harvesting 50 acres a year with a binder and hiring the threshing done with a stationary thresher is considerably greater than the cost for the work if done by a header and separator, as the depreciation and interest costs for a header are about one-half of those for a binder. For 100 to 200 acres a year there is also a substantial difference in cost in favor of the header. A header can be used on acreages that do not run much over 300, but the binder should not be depended upon to harvest much over 200 acres yearly. For 100 acres a year the cost with a 16-foot combine is slightly more than for a binder and considerably more than for a header, but for 200 acres and more the difference steadily increases in favor of the combine.

The total charge for harvesting and threshing 275 acres, the average acreage harvested in 1927 with 10-foot combines in the Corn Belt, was about $1.95 per acre, as compared with about $3.64 per acre when the work was done by two binders and a hired separator. In cutting 640 acres with 16-foot combines in the Great Plains the cost was about $1.65 per acre, as compared with about $3.55 per acre when the work was done by three binders, and $3.13 for two headers and a hired separator.

Direct cash or out-of-pocket expenses, if the help of two men is available, amounts to 34 cents per acre for a 10-foot combine in the Corn Belt, as compared with $2.03 for harvesting with the binders and threshing with a hired separator; for the 16-foot combine in the Great Plains the out-of-pocket expenses would be 33 cents per acre as compared with $2.10 and $2.35 per acre, respectively, for the binders and headers when the threshing is done with a hired separator.

LENGTH OF HARVEST SEASON

Grain crops under all conditions are ready for harvesting with a combine about 7 to 14 days after they are ripe enough to be cut with a binder. The proportion of the time in which a combine will be used during any harvesting season is chiefly dependent on weather

conditions, as harvest is seldom completed without some delay from rain. In addition to delays from inclement weather some time may be lost in waiting for or making repairs to the machine. The number of days available for cutting the crops on most farms is ample; yet some operators who harvest grain sorghums, flax, or soy beans may be pressed for time in which to complete their harvest. Wheat harvest also is sometimes delayed to the extent that combine operators have difficulty in completing harvest, as was the case in Montana in 1926. Such delay may also arise where grain is harvested with a binder, as in Illinois in 1926, where much of the small grain was lost or not threshed until the spring of 1927, because of excessive rains, but combine operators were able to complete their harvest before the rainy weather set in, thus saving their entire crop.

In the Great Plains wheat can stand in the field for three or four weeks after ripening, without loss, and in the Corn Belt wheat can stand two or three weeks, but in the East it should be cut within two weeks after ripening, so that harvesting will be completed before many of the plants have broken over.

As oats usually should be cut within four or five days after ripening in order to evade the breaking over of the stalks, the harvest season for this crop is limited.

Soy beans frequently are left in the field two or three months after ripening. They have been harvested with a combine successfully in midwinter. Stormy weather and slow drying of the crop in the fall serve to prolong soy-bean harvest longer than the harvest of any of the grain crops.

WEATHER CONDITIONS

Weather at harvest time is the most important factor in determining the acreage that can be harvested with a machine during a given period. The number of rainy days is not an exact indication of the delays caused in harvesting. A heavy rain causes only a slightly longer delay in combining than does a light rain, because the standing grain will absorb only a limited quantity of moisture and it dries rather quickly as soon as the weather clears. A rain of 2 inches or more usually delays shock threshing as long as it delays combining. A rain followed by cloudy weather may delay harvest several days, whereas a shower followed by a clear sky may cause little delay. Rains that occur in late afternoon may not interfere with harvest for more than a few hours. Intermittent rains occurring at harvest time may cause a loss of valuable time, the amount of time lost depending upon the duration and frequency of the rains and the stage of ripeness of the crop.

The average number and percentage of days during the small-grain harvest season on which rains of 0.1 inch or more occurred during a 13-year period are shown for several stations in Figure 6.

Humidity and dew, although of far less importance than rainfall during the harvest season, govern to some extent the time when harvesting can begin in the morning and will stop at night. Evaporation is greater and humidity is less in the Great Plains than in the Corn Belt or in the Eastern States. This would indicate that there would be more delay in harvesting after rains farther east than in the Great Plains. During periods of dry weather the humidity in the

early morning is very similar in the Great Plains and in the Corn Belt. This would indicate that at times delays in starting combines in the morning would be but little greater in the Corn Belt and in the Eastern States than in the Great Plains region and probably no greater than in the northern spring-wheat area.

In certain areas most farmers feel that hail is their greatest risk at harvest time. There is an added risk when grain is harvested with a combine since the crop must stand 7 to 14 days longer than when it is cut with a binder. Hail is a much greater risk to crops in that portion of the Great Plains in which combines are now used extensively than in grain-growing sections east of the Mississippi River. In some sections fire is a greater risk than hail.

High and prolonged winds occurring when the grain is ripe and dry occasionally cause heavy shattering losses. Such losses may occur in any field, irrespective of the method of harvesting.

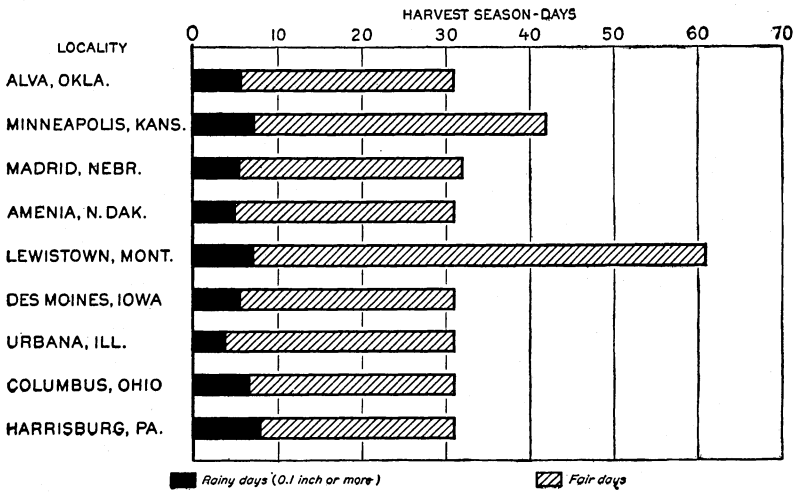

FIG. 6.—WEATHER CONDITIONS DURING HARVEST SEASON FOR SMALL GRAINS, AT NINE SELECTED STATIONS; AVERAGE FOR 1914 TO 1926, INCLUSIVE

The percentage of rainy days was highest in Pennsylvania and lowest in Montana and was lower in Illinois, Iowa, and North Dakota than in Oklahoma. The term "rainy day," as here used, means any day during which 0.1 inch or more of rain fell.

HARVESTING LOSSES

Losses resulting from different methods of harvesting and threshing show that under ordinary conditions the combine does a good job of harvesting and under favorable conditions the work it does compares favorably with that done with a binder or header.

The chief source of loss in harvesting grain with the combine is found in the heads which drop in front of the cutter bar or are thrown out by the reel. Some heads on short or lodged stems are completely missed by the cutter bar. Some combines allow considerable quantities of grain and heads to be thrown from the feeder box in front of the cylinder.

The losses occurring when winter wheat is harvested with combines in the Great Plains are practically all less than 3 per cent. Greater losses occur only in partly lodged grain, on rough land,

with poor machines, with careless operators, or in very windy weather. In the Corn Belt and in the Eastern States harvesting losses are somewhat higher than in the Great Plains because more of the grain is lodged and because of greater interference from weeds.

The average loss in harvesting 190 fields of hard winter wheat with combines in the Great Plains in 1926 was 2.6 per cent, as compared with 3.3 per cent with headers and 6.1 per cent with binders. In South Dakota in 1927 the average losses in harvesting spring wheat were 1.8 per cent with combines, 2.7 per cent with headers, and 3.0 per cent with binders. In the Corn Belt the losses in harvesting with the combine and binder are about equal. East of the Corn Belt the losses in combining are similar to or slightly greater than those incident to harvesting with the binder because more of the grain is lodged during harvesting when the combine is used.

Losses in harvesting oats with the combine will exceed those with the binder unless the combining is done before the oat plants break over. The breaking over of the ripe stems is a serious handicap in combining oats.

The losses in harvesting soy beans with a combine are considerably less than those incurred in harvesting them by other methods.

When grain crops stand for several weeks after ripening the stems gradually weaken and break. Wheat and rye usually stand up longer than do oats and barley. Some thin-stemmed varieties appear to stand as well as thick-stemmed varieties. Damp weather appears to favor this breaking over; consequently the difficulty is confined largely to the Eastern States. Combines usually will cut the broken-over grain cleanly, but many heads may drop in front of the cutter bar. Harvesting a down crop is slower, and losses are greater because all of the straw must be threshed, and if legumes have been sown with the crop, the top of these plants may be cut off, or more weeds may be cut.

Weak-stemmed varieties of grain, which frequently lodge before maturity, are objectionable, no matter what method of harvesting is used. Combine operators agree that lodged grain can be harvested with a combine as well as, or better than, by any other method. The sickle guards on many combines curve downward and tend to lift the leaning and prostrate stems. The reel of a combine can be adjusted to lift up the lodged stems better than does a binder reel. As the crop is handled only once by a combine, some heads are saved which would be lost if the grain was bound.

Appreciable shattering of wheat seldom occurs in the Great Plains and is of rare occurrence under the more humid conditions in the East except when certain easily shattered varieties are grown. The hard red winter, hard red spring, and durum wheats of the Great Plains are not likely to shatter unless harvesting is much delayed or unless high winds blow.

THRESHING LOSSES

The average threshing losses from grain carried over with the straw are slightly larger with combines than with separators. These losses are due chiefly to the inexperience of combine operators, although in

weedy and lodged grain certain threshing losses in combining are unavoidable. Under ordinary conditions good clean threshing is just as easily accomplished with a combine as with a separator. Many combine operators do excellent threshing. The chief threshing losses are from grain blown out over the rear of the machine by too strong a blast of air or carried over with thick layers of chaff and weeds. These losses can be greatly reduced by proper adjustment and operation. Combines can also be adjusted to thresh the grain from the heads almost completely even when the straw is tough and the grain too damp for safe storage. Losses from grain left in the heads seldom exceed 0.5 per cent.

WEEDS.

Numerous green weeds such as sunflowers, wild sweet potatoes, mustard, Russian thistle, ragweed, smartweed, and milkweed, also large sweet-clover plants, greatly interfere with combine threshing as they choke the machine, carry over grain, and increase the moisture content of the grain. Large mature weeds of certain kinds sometimes choke the reel or cutter bar. Weeds are most troublesome in wet seasons, when harvesting is delayed and the crop is broken over. Weeds which are not tall enough to be cut by the cutter bar do not interfere with combining. If grain crops are cut with the binder the weeds dry before threshing and no moisture is absorbed from the weeds or weed seeds by the grain.

QUALITY AND CONDITION OF COMBINED GRAIN

The average moisture content of combined grain usually is higher than in grain threshed from the shock.

The average moisture content of 40 samples of wheat combined in Indiana in 1927 was 15.7 per cent, as compared with 14.4 per cent in seven samples threshed from the shock. In South Dakota, where the harvest season was damp, the combined wheat averaged 17.7 per cent moisture and the shock-threshed wheat 13.1 per cent. In 1926 in the Great Plains the moisture content of combined wheat was about 2 per cent more than in shock-threshed wheat. Wheat usually should contain not more than 14 per cent moisture in order to keep in storage.

Inexperienced combine operators frequently harvest when the grain is too damp. Experienced operators, on the other hand, are more inclined to wait until the crop is fully ripe before beginning to harvest, and they allow the crop to dry after each rain before resuming harvesting. If combine harvesting is postponed until the crop is in proper condition there will be little danger of the grain spoiling in storage. The moisture content of damp wheat or other grain standing in the field frequently drops 3 to 4 per cent in a day if the weather is dry and clear and the humidity is low. Combined grain is accepted at the local markets at the same price as grain threshed from the shock or stack if it has been harvested at the proper time.

Damp grain either must be dried by being spread out or by being put through an artificial grain drier, or it must be mixed with dry

grain in order to keep it from going out of condition. As most of the grain driers are located at the terminal markets, only a limited quantity of damp grain can be handled at the local elevators. Economical grain driers for use on the farm have not yet been developed, and ventilated bins are not effective in drying grain which is distinctly damp. Grain can be dried by being spread in a thin layer on a barn floor and frequently stirred, but this method of drying has its limitations.

Most of the combined soy beans have contained less than 14 per cent moisture and have been drier than those harvested by other methods.

SAVING THE STRAW

The straw from combines usually is scattered on the land with straw spreaders or is merely dropped in windrows from the rear of the machines. Some combines are equipped with straw bunchers which drop the straw and chaff in piles. Sometimes the straw and stubble are burned in order to facilitate plowing. Most of the straw from threshing machines in the West is wasted, although some of it is returned to the land as manure. Consequently there is a greater addition of organic matter to the soil in combine harvesting than in harvesting by any other method. Straw is more evenly distributed with a straw spreader on a combine than by any other method.

Straw from combines can be saved by being gathered from windrows with a hay loader, or by the bunches being loaded by hand or by a sweep rake and baled in the field. Farmers sometimes harvest a part of their crop with a binder and thresh the bundles with the combine in order to save some straw for feed and bedding. A few farmers cut their grain as high as possible with a combine and cut the stubble later with a mower.

When a legume has been sown with a grain crop and the grain is harvested with a combine the following hay crop will be mixed with decayed straw. The straw that is left usually is not heavy enough to smother the young legume plants and may even prove a protection. There is less clipping of the legume crop with a combine than with a binder because the stubble is cut higher.

ACREAGE ON WHICH A COMBINE WILL BE ECONOMICAL

Many combines are bought for use primarily on the home farm, but some are bought with the idea of doing additional work for others as a means of partially paying for the combine. The minimum acreage for which a combine will be profitable is determined largely by the cost of alternative methods of harvesting. The acre cost is less for a large than for a small acreage.

In the Corn Belt, where the cost of labor is less than in the Great Plains, there should be about 80 acres for a 10-foot combine before the cost of combining will be less than the cost of harvesting with a binder and threshing with a stationary separator. On the basis of the cost of operating in localities of the Great Plains in which binders are used in preference to headers, an operator may find his harvest costs decreased by a 10-foot combine if he has 60 acres or more of grain to cut. With a 15-foot machine a farmer must have at

least 100 acres before the costs will be less than when harvesting is done with a binder. The minimum acreage that justifies a combine in localities in which it is customary to use headers would be about 100 for the 10-foot and at least 160 acres for the 15-foot machine.

In Illinois and Indiana the operators' estimates of the least acreage of all crops for which a combine would be profitable were about 150 acres for the 8-foot, 170 acres for 9-foot, 180 acres for 10-foot and 300 acres for the 12-foot machines. The average of estimates made by 220 farmers in the Great Plains as to the least acreage for which it would be profitable to own a combine ranged from about 130 acres for the 8-foot machines to 400 acres for the 20-foot machines. If the combine is used each year for some custom work the acreage of owned grain necessary for profitable operation of the combine would be smaller than either the computed figure or the estimate of the operators. In most cases the owners who made these estimates were considering points other than the difference in cost of harvesting by combines and by other methods. Some of the points which these operators considered were as follows: The first cost of the outfit, money available to pay for it, use of the combine for custom work, power requirements, salvage value and age of present harvesting equipment, and the supply of family labor.

The combine can be used in small fields as well as in large ones. The machines can turn a square corner within the space of the previous swath. A tractor-drawn combine usually turns a corner more quickly than does a horse-drawn binder or mower. The only disadvantage which a combine has in small fields in comparison with a binder is that more grain is crushed down on the first round. The smaller the field the greater the proportion of the crop that is lost in this way. If the grain in the borders of the field is cut previously with a binder or mower, a common practice even in large fields in the Pacific Northwest, no grain will be crushed down on the first round of the combine.

Combines are now built with an over-all width from 8 to 19 feet when arranged for transporting. Nearly all models will pass through a 16-foot gate. As it is usually easier to build wide wire gates than to prepare a combine for transport repeatedly, on many farms in the Corn Belt and in the Eastern States wider gates will have to be provided or sections of fence will have to be taken down to permit the easy moving of combines.

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